ON HYMENOLEPIS CARIOCA (MAGALHAES) AND H. MEGALOPS (NITZSCH) WITH REMARKS ON THE CLASSIFICATION OF THE GROUP

By B. H. RANSOM

WITH THREE PLATES

Hymenolepis carioca (Magalhaes)

One of the most common tapeworms of chickens in Nebraska, Iowa, and Missouri is the form noted by Stiles (96, p. 59) under the title of *Taenia* sp. Conard MS. Through the kindness of Dr. Conard I have had the privilege of seeing his manuscript, as well as his material and preparations, which have proved of great assistance in the identification of my specimens.

The worm in question is very slender and delicate. Scarcely larger than a coarse thread at its posterior end, it tapers gradually anteriad, becoming exceedingly tenuous at the neck. The length ranges from 30 mm. to 80 mm. The width at the neck varies between 75 μ and 150 μ, at the posterior end from 500 μ to 700 μ. The margins of the strobila are serrate (fig. 9), although the appearance of serration is often obliterated when the segments are much expanded (fig. 1). The posterior margins are not prolonged backward to any extent, so that there is little or no overlapping of the segments. Throughout the strobila the width of the segments is three to five times, or more, greater than their length; the worm is thus of the type with short segments such as *Hymenolepis diminuta* and others of the genus.

The head (fig. 8) is small, somewhat flattened dorso-ventrally. It measures from 140 μ to 160 μ in length, 150 μ to 215 μ in width, and 100 μ to 140 μ in thickness. The suckers are shallow and slightly oval, with a diameter of 70 μ to 90 μ. The rostellum (fig. 8, *ros*) is like that of *Hymenolepis diminuta*. It measures as it lies withdrawn into the head, 25 μ to 40 μ in diameter by 90 μ to 100 μ in length. As in *H. diminuta,* there is a small pocket (*rp*), lined with cuticula, and opening at its tip. The rostellum is unarmed. A head, sectioned *in situ* with a piece of intestine, possessed, upon the suckers, hooks (fig. 3) which were very small and caducous. The ventral root is long, while the dorsal root is only a mere knob. The slender, pointed blade forms an angle of 90° to 120° with the ventral root. They are of the same type as the hooks from the suckers of *Davainea Friedbergeri* (Stiles 96, fig. 237). The smallest have a blade 4 or 5 μ in length, and a ventral root of 2 μ to 3 μ. The blade of the largest hooks measures 6 μ to 7.5 μ, the ventral root 2 μ to 4 μ. The round neck measures from 0.6 mm. to 1.5 mm. in length, and 0.075 mm. to 0.15 mm. in width.

The genital pores are situated upon the right-hand margin of the strobila, normally somewhat in front of the middle of each segment (fig. 1, *gc*). Very rarely a pore will be found on the left-hand margin. The cirrus pouch (*cp*), seminal vesicle (*vs*), and seminal receptacle (*sr*) are usually easily recognizable in toto specimens. In ripe segments the last (fig. 9, *sr*) is quite apparent by reason of the mass of spermatozoa it contains. The last 30 to 100 segments are crowded with embryos so that the median field of each is fully occupied (fig. 9), and the embryos of one segment are separated from those of the adjacent one only by a double thickness of the thin uterine wall. Since the segments do not tend to break off singly from the strobila as they become ripe, and since the embryos which they contain form practically a continuous mass extending unbroken from one proglottis to the next, if a portion of the worm be broken off from its posterior end the entire series of proglottides will constitute what is in effect but a single embryo sac.

Four membranes may be distinguished surrounding the onchosphere (fig. 6). The space between the middle two is filled with a granular mass, and potentially, as well as actually in some cases, these two membranes, by close approximation, constitute but a single envelope. The three outer layers are thin and colorless, while the innermost next the embryo is often slightly tinged with yellow and is usually thicker than the others.

MEASUREMENTS OF EMBRYOS

SIZES IN MICRONS	LEAST	GREATEST
Outer envelope	36 x 36	70 x 75
Outer middle envelope	30 x 30	65 x 60
Inner middle envelope	26 x 26	40 x 35
Inner envelope	24 x 16	29 x 21
Onchosphere	18 x 14	27 x 19
Hooks (fig. 5)	10	12

A comparison of the points given above with the description and figures by Magalhaes (98) of *Davainea*(?) *carioca* will show that the *Taenia* sp? of Conard is the same as the form which Magalhaes has described. The presence of hooks upon the suckers might appear as a confirmation of the supposition made by Magalhaes that the species is a *Davainea,* but beyond this characteristic it possesses none of the peculiarities of that genus. The fact alone that it has a definite and persistent uterus precludes the possibility of such a generic relationship, and furthermore its close structural resemblances to the type of *Hymenolepis* justify its immediate reference to that genus.

The possession of armed suckers by a species of *Hymenolepis* is significant in that it demonstrates how little importance can be attached to such a character in establishing generic relationships. In fact, in many cases it can not be considered of more than specific value. Braun (94–00, p. 1718) has gone so far as to assign to this character a rank even higher than generic, by making it the sole distinguishing mark of the subfamily Davaineïnae, comprising the genera *Davainea, Echinocotyle,* and *Ophryocotyle.* He has thus bound together three groups of forms resembling each other only in the possession of armed suckers, and at the same time has separated the group *Davainea* from other forms which bear close resemblances to it in many respects, but do not have hooks upon the suckers. Beyond the fact that *Echinocotyle* and *Ophryocotyle* have armed suckers there can be no excuse, so far as our knowledge of their anatomy goes at present, for grouping them with *Davainea.* Moreover, such genera as *Monopylidium* and *Cotugnia,* although their suckers are unarmed, resemble *Davainea* too much to be placed in a separate subfamily, and certainly have more in common with the latter than with *Hymenolepis* or *Choanotaenia*. The subfamily Davaeneīnae consequently can no longer be maintained upon its original basis.

Internal Anatomy.—*Nervous System.*—Owing to the small size of the worm only a few of the details of the nervous system could be determined. There is, however, a well-defined bilobed ganglionic mass (fig. 10, *cg*) situated at the base of the rostellum. From it nervous processes (*an*) pass anteriad along the sides of the rostellum, within which, also, there is a considerable amount of nervous tissue. The lateral longitudinal nerves (*ln*) arise from the postero-lateral corners of the ganglia (figs. 1, 7, *ln*). The accessory lateral nerves are very small and only occasionally evident in the segments, lying a short distance dorsal and ventral from the main nerves.

Musculature.—Extending throughout the strobila are four dorsal and four ventral muscle strands, or small compact bundles, composed of only a few fibers (fig. 7, *im*). In the scolex they attach to the suckers, two to each. These slender strings comprise the inner longitudinal muscle layer, and correspond to the eight inner longitudinal muscle bundles of *Taenia inflata* Rud. as described by Jacobi (98) and of *Taenia microsoma, Drepanidotaenia anatina,* and another undetermined species as described by Wolffhügel (00). The outer layer of longitudinal muscles (*om*) consists of about one hundred muscle strands similar to the inner muscles and like them continuous from segment to segment. The origin of these muscles is similar to that of the outer longitudinal muscles of *Anoplocephala perfoliata* as described by Lühe (94, 96), *i. e.,* they are the prolongations of the longitudinal subcuticular muscles of the scolex. A layer of diagonal muscles (fig. 7, *dm*) is prominent in the older segments just outside the outer longitudinal layer. A transverse muscle system is represented only by a few slender isolated fibers (*tm*), restricted mostly to the extreme anterior and posterior ends of the segment, as is the case in many other forms of the genus. A few dorso-ventral fibers are also found in these regions.

The sac-like rostellum (fig. 10, *ros*) possesses a muscular wall consisting of an outer layer of longitudinal and an inner layer of circular fibers, as in *H. diminuta* (Zschokke 88).

Excretory System.—The longitudinal excretory canals unite in the scolex to form a ring at the base of the rostellum. From this ring four small vessels, about 1 μ in diameter with comparatively thick, highly refractive walls, enter the rostellum a short distance in front of its base. Near the middle of the rostellum the dorsal vessel on each side unites with the ventral vessel so that two closed loops are formed. Branches of the excretory system apparently similar to these loops have been described by Mingazzini (99) for *Hymenolepis murina.* I have also found exactly similar loops in the rostellum of *H. diminuta,* readily apparent in cross-sections. The ventral excretory vessels are larger than the dorsal vessels from the beginning (fig. 10, *vc, dc*). In the scolex the former measure 6 μ, the latter 4 μ. The ventral vessels later attain a size of 25 μ to 40 μ; the dorsal vessels retain their original small diameter or become even more attenuated. Transverse vessels connect the ventral vessels at irregular intervals of two to seven segments, usually at an interval of about five.

Reproductive Organs.—The three testes (figs. 1, 2, 7, *t*) lie near the middle of the segment and usually two to the left and one to the right of the median line. The vasa efferentia (fig. 2, *ve*) unite near the median line to form the vas deferens (*vd*) which runs forward to a point dorsal to the inner end of the cirrus pouch. It here turns to the left, then curves ventrad, and finally, bending to the right, enters the base of the latter. Between the first and second turns of the vas deferens, dorsal to the cirrus pouch, there is an enlargement, the vesicula seminalis (figs. 1, 7, *vs,* fig. 2, *vsa*), which may attain a size of 50 by 70 μ. Scattered over its surface, more especially at its distal end, are numerous large cells drawn out at one pole into a narrow process (fig. 7, *pc*).

The body of one of these cells is some 6 μ or 8 μ in diameter, while the length of the process, which has a diameter of about 1 μ, is 12 μ to 14 μ. The protoplasm is compact and finely granular, and each cell contains a spherical nucleus 2 μ in diameter, with a single prominent nucleolus. These cells are to all appearances exactly similar to the cells found in the same position but in much greater numbers in *Taenia transversaria, Taenia expansa,* and *Calliobothrium coronatum,* described by Zschokke (88) as prostate glands. I was unable to demonstrate, however, that these cells opened into the cavity of the vas deferens in *H. carioca* as described and figured by Zschokke. In the wall of the vas deferens between the vesicula and the cirrus pouch a few circular fibers are sometimes evident (fig. 7).

The cirrus pouch (fig. 1, *cp*) in adult segments measures from 120 μ to 175 μ in length by 15 μ to 18 μ in diameter. It is almost cylindrical, rarely perfectly straight, but bent more or less, usually toward the ventral surface in a gentle curve (fig. 7). Along its outer surface there are about twenty prominent longitudinal muscle bands, 2 μ to 3 μ in thickness and slightly less in width (fig. 4, *mp*). Similar muscle bands have been described in *Taenia depressa* by Fuhrmann (95), in *Taenia inflata* by Jacobi (98), in *Fimbriaria fasciolaris* and *Dicranotaenia coronula* by Wolffhügel (00), as well as in other forms by different authors. *Hymenolepis carioca* is remarkable by reason of the small number of these bands, and their relatively large size. Surrounding the middle part of the cirrus pouch is a layer of cells (figs. 4, 7, *my*), which, from their intimate relation to the muscle bands, are to be interpreted as myoblasts. They possess nuclei 3 μ in diameter, each containing a deeply staining nucleolus. These myoblasts are most prominent in the young segments before spermatozoa are found in the vas deferens. Circular muscles are lacking, and the membrane of the cirrus pouch (fig. 4, *sm*) lies directly beneath the muscle plates. Upon entering the cirrus pouch the vas deferens is much constricted (fig. 7). In thickness and general appearance, the wall of this narrow portion of the vas deferens resembles the membrane of the pouch, which seems to have turned in at this point to form a narrow tube through which the vas deferens passes. Beyond this narrow portion the vas deferens is dilated to form a second seminal vesicle (figs. 4, 7, *vs'*) The wall of this part of the vas deferens is surrounded by circular fibers which are most prominent in the region occupying the middle third of the pouch (fig. 7). At a point about one-third the length of the pouch from its distal end, the vas deferens becomes narrow again, to form the cirrus (fig. 7, *ci*), a thin tube not more than 1 μ in diameter, without apparent spines or musculature. In the space surrounding the vas deferens within the cirrus pouch are numerous small nuclei, 1 μ to 2 μ in diameter (figs. 4, 7). Both the cirrus pouch and the vagina are dorsal to the nerve and the excretory canal. From the diagonal muscles of the proglottis fibers turn in to attach to the outer portion of the cirrus sac, serving thus as protractors (fig. 7, *pr*).

The genital cloaca (fig. 1, *gc*, fig. 7) is from 12 μ to 36 μ deep, surrounded by longitudinal and circular fibers, the latter next the cuticula. The longitudinal fibers come from the diagonal system, or from the subcuticular longitudinal muscles, and attach to the tip of the cirrus pouch to form part of the system of protractors.

The opening of the vagina into the cloaca is ventral and posterior with respect to the cirrus. The vagina (figs. 1, 7, *vg*) is at first narrow, being only 1 μ in diameter. At a distance of 8 μ to 10 μ from its distal end, it is surrounded by a small bulb-like body (fig. 7, *vgs*), consisting of short, thick, muscular fibers running in a spiral. This bulb is apparently homologous to the vaginal sphincter of *Drepanidotaenia lanceolata* described by Wolffhügel (00a). Beyond the sphincter the vagina gradually enlarges, and swells out into a seminal receptacle, which may grow to be very large, so as to reach forward to the anterior limits of the segment, and even crowd in against the organs of the next. Inward it may extend considerably beyond the proximal end of the cirrus sac.

The ovary (fig. 1, *ov*) is a sac-like organ elongated transversely, faintly bilobed, or even slightly trilobed, as in *Taenia inflata* (Jacobi 98), lying in the posterior half of the proglottis toward its ventral surface. At its maximum it extends from one excretory canal to the other. The ova reach a diameter of 10 μ before leaving the ovary.

The yolk gland (*yg*) is spherical or ovoid, 30 μ to 40 μ in diameter, situated posterior and dorsal to the ovary, near the median line.

The uterus at first is simply a solid cord of cells (fig. 1, *ut*) extending transversely along the anterior border of the ovary and reaching the excretory canals on either side. With progressing development a cavity is formed by a hollowing out of the cord, and the uterus becomes a thin-walled sac which grows backward on the dorsal side of the ovary. As the uterus enlarges the ovary quickly disappears, and the former soon comes to occupy all the available space within the proglottis (fig. 9). The wall of the uterus consists of a thin membrane (fig. 7, *ut*) upon the outer surface of which are numerous small cells elongated sagittally, and fine fibers which seem to be extensions of the pointed ends of the cells. During the growth of the uterus a number of infoldings arise in its wall, mostly in the form of tubular processes, a few of which meet and fuse to form slender, bridge-like connections, so that finally the uterus is modified to a slight degree from its original simple sac-like condition.

With regard to its reproductive organs as well as in other respects *Hymenolepis carioca* is quite comparable to *H. diminuta* (Rud.), the type of the genus. Both forms possess unilateral genital pores, reproductive canals dorsal to the nerve and excretory canals, three testes, a large sac-like vesicula outside the cirrus pouch, and a second smaller one within. A large seminal receptacle, a more or less bilobed ovary, and a yolk gland posterior and dorsal to the latter are also present in both. The uterus in both arises first as a transverse tube anterior to the ovary, later filling the segment, and in each case is not a simple sac, but characterized by a greater or less number of inturned processes and bridges of tissue developed from its walls. Apart from the major complications arising during the growth of the uterus of *H. diminuta* as described by Zschokke (88), there are a great number of small processes extending from the wall of the uterus in among the eggs, which are quite like the comparatively insignificant infoldings of the wall of the uterus in *H. carioca.* The similarity between the eggs is obvious.

Hymenolepis megalops (Nitzsch)

Was first found by Nitzsch in the intestine of *Anas boschas* and *Dafila acuta.* Creplin (25) found in the rectum of *Anas marila* a specimen 54 mm. long and 2.25 mm. wide posteriorly, possessing a head almost 2.25 mm. in width, with a very short, obtuse rostellum. Later he found five much smaller specimens of which he gave incomplete descriptions. Two figures by Creplin (29) are reproduced by Braun (94–00). Dujardin (45) took two specimens from an *Anas boschas,* one of which was 52 mm., the other 35 mm. in length. He gives two figures of detached proglottides, and in addition a diagnosis of the form upon the basis of its external anatomy. Diesing (50, 64) merely adds to the list of hosts. Stiles (96) gives a short synopsis of *Taenia megalops* from previous authors, with drawings of a specimen taken from *Anas braziliensis* from the collection of the Vienna Museum. While he is of the opinion that from existing descriptions the worm can not be recognized with any degree of certainty, I believe, on the other hand, that the external characters are peculiar enough to enable one to identify it easily, and with little or no chance of error.

Four individuals of this tapeworm were collected by me, March, 1901, from the rectum of a pintail duck, *Dafila acuta,* shot on the Missouri river near Columbia, Mo. Two of the worms were young and immature. The other two were larger, and considerably more advanced in development, as several of the posterior segments contained embryos which were yet, however, without hooks.

The length of the largest specimen was 35 mm., and the width, almost uniform from head to tail, 0.55 mm. just behind the head, and 0.72 mm. at a point near the posterior end. The number of segments was 195. The head is large, 1 mm. in length by 1.1 mm. in width and thickness, and, viewed from the front, square with rounded angles (figs. 11, 17). The suckers are spherical, 0.4 mm. in diameter, and open forwards and outwards, near the four angles of the flattened anterior surface of the head. In the center of the anterior surface is the small orfice of the cavity of the rostellum. The length of one of the small specimens was 4 mm., its width 0.45 mm., and the number of segments about 70. The head measured 0.45 mm. in length by 0.75 mm. in width and thickness.

Strobilation begins immediately behind the head, and is very distinct almost from the first, by reason of the deep constrictions between the segments. These constrictions mark off a peripheral portion of the segment from the central portion (figs. 18, 19, 20). The central portions are continuous, while the peripheral portions are separated from one another by the constrictions. The outer surface of the projecting rims of the segments is marked by a number of longitudinal grooves (fig. 20, *gr*) noticed by Dujardin (45), which give the surface of the worm a corrugated appearance. The under surface of the rims is marked by tiny longitudinal ridges in the cuticula, folds made necessary by the decrease in area of the under surface when the rims, instead of extending laterally as in the youngest segments, come to point backward, as they do more and more with the increasing age of the segments.

MEASUREMENTS

	25TH PR.	175TH PR.
Width of proglottis from edge to edge of rim	550 μ	720 μ
Width of central portion of proglottis	350 μ	440 μ
Length of central portion of proglottis	30 μ	290 μ
Length of entire proglottis	30 μ	490 μ
Thickness of proglottis from edge to edge of rim	400 μ	280 μ
Thickness of central portion of proglottis	200 μ	240 μ

The genital pores (figs. 15, 19, *gc*) are unilateral, situated on the right-hand margin, and marked by a slight prominence. A line drawn transversely through the very base of one segment will pass through the margin of the preceding segment very near its genital pore. The main body of the proglottis thus lies anterior to the genital pore, with only the projecting rim extended behind.

Through Dr. Ward I am indebted to Dr. C. W. Stiles for the opportunity of comparing with my specimens one from the U. S. National Museum, the same from which the figures by Stiles (96) were drawn. This worm was much contracted and considerably shorter than my largest specimen, but possessed a few more segments, 200 to 210 in all, the posterior ones of which were transparent enough to show that they contained six-hooked embryos.

The embryos at the latest stage (fig. 13) reached in my specimens are round, 25 μ to 30 μ in diameter. The clear, transparent shell has a thickness somewhat over half a micron. The embryo proper measures 15 μ. Lying close against the inner surface of the shell is an ill-defined layer of flocculent substance, within which are three or four, possibly more, nuclei 2.5 μ to 3.5 μ in diameter, each containing a large nucleolus. A six-hooked embryo (fig. 14), from the specimen furnished by Dr. Stiles, possessed an outer shell about 45 μ in diameter, and a somewhat thicker (2 μ) inner envelope 22 μ x 27 μ in diameter, with hooks 12 μ in length. A very thin membrane, which usually lies so closely applied to the outer envelope as not to be distinguished, sometimes, under the influence of changes in osmotic pressure, draws away from the latter and thus becomes apparent, as shown in fig. 14.

Internal Anatomy.—The rostellum (figs. 12, 16, *ros*) is bounded by a layer of muscles (fig. 12, *rm*), some of which are longitudinal and some circular. In the parenchyma of the rostellum, just beneath the cuticula lining its cavity, is a dense layer of cells (fig. 12, *rc*), resembling somewhat the subcuticular cells elsewhere, but much more thickly crowded, and with more prominent nuclei.

Nervous System.—The nervous system shows an arrangement resembling in general that of *Taenia crassicollis* and *T. perfoliata* as described by Cohn (98). My observations agree less closely with those of Tower (00). The main lateral nerves (fig. 12, *ln*) in the scolex bend toward one another and are joined just behind the rostellum by a transverse commissure (*co*), which consists of two parallel strands of nerve fibers (fig. 17) as in *T. perfoliata.* The two halves of the commissure are connected by fibers running diagonally from one to the other, and between them lie numerous ganglion cells. Surrounding each sucker near its posterior pole is a circular ring or zone of nerve fibers, lying in the same horizontal plane as the transverse cerebral commissure, and joined to it at its point of union with the lateral nerve. Fibers from these nerve zones run in various directions over the surface of the suckers, and at intervals tufts are given off which extend radially toward the surface of the head (fig. 17). In the regions where the zones approach one another they are connected by interlacing fibers. From the transverse cerebral commissure near the median line, a dorsal and a ventral pair of parallel nerves (fig. 17, *dd, vv*) come off at right angles and extend almost horizontally dorsad and ventrad respectively to the nerve zones, joining them in the region where they approach nearest the median line. Fibers which cross at right angles between the two strands of the commissure establish a continuity between these dorsal and ventral nerves.

This cerebral complex corresponds roughly to that of *Taenia crassicollis* as given by Cohn (98). While the cerebral commissure connecting the main lateral nerves in *T. crassicollis* is long, in *T. megalops* it is short and moreover double as in *Taenia perfoliata.* The two pairs of nerves (*dd, vv*) mentioned above form a dorso-ventral commissure composed of two parallel right and left halves. The dorso-ventral commissure in *T. crassicollis* is single in the region where it crosses the transverse commissure, but separates fork-like dorsally and ventrally. The inner quadrants of the nerve zones of the suckers correspond to the commissures in *T. crassicollis,* which connect the main lateral nerves with the forks of the dorso-ventral commissure. The remaining portions of the zones together correspond to the "polygonal commissure." Nerves apparently homologous to the accessory lateral nerves (fig. 12, *na*) join the cerebral complex some distance laterad from the main lateral nerves, about 90° measured along the circumference of the nerve zones. In *T. crassicollis,* on the other hand, the main lateral nerves and the accessory nerves of each side have a common point of origin. The dorsal and ventral median nerves join the complex (fig. 17, *nm*) near the ends of the dorso-ventral commissure, as in *T. crassicollis.* The median and accessory lateral nerves are connected behind the complex by numerous commissures with one another and with the main lateral nerves. In *T. megalops,* while these eight nerves are prominent through some distance just behind the cerebral complex, they seem to disappear entirely in the posterior part of the scolex, and if they are present in the proglottides are too small and insignificant to be traced. From the point at which each lateral nerve joins the cerebral commissure, two nerves (fig. 12, *rvn*), the "apical branches" (Cohn) of the lateral nerves, extend forward on each side to join the rostellar ring (figs. 12, 16, *nr*) right and left. From each of these apical branches a nerve (*rn*) comes off to enter the rostellum. The apical branches of the median nerves join the rostellar ring dorsally and ventrally (fig. 16). From the point of union of each of these eight nerves with the ring, a branch of nerve fibers passes outward over the surface of the adjacent sucker. A number of nerves extend forward from the same points.

The lateral nerves are joined in three regions (fig. 19, *ag, mg, pg*) in each proglottis by dorsal and ventral commissures, as in *T. perfoliata.* The posterior commissures (fig. 18, *pdc, pvc*) are the most prominent and lie between the two longitudinal muscle layers, while the other two pairs lie just within the inner layer (fig. 20, *adc, avc*). In connection with each commissural ring of the proglottis in *T. perfoliata,* all three of which lie inside the inner longitudinal muscle layer, Cohn describes a second ring which lies between the muscle layers and joined with the former by radial fibers passing between the muscle bundles. It is this outer ring which forms the posterior commissures in *T. megalops.* An inner posterior ring, if present, is scarcely developed. Fibers faintly indicating such a ring are sometimes seen (fig. 18, *x*).

Musculature.—From the suckers powerful muscles of the inner longitudinal layer extend backwards grouped at first mostly in eight bundles (fig. 12, *im*). This muscle layer, which is very heavy and prominent in the anterior segments (fig. 18, *im*), becomes progressively thinner posteriad by the gradual reduction in size of the bundles (fig. 20, *im*). The outer layer (fig. 18, 20, *om*), consisting of a great number of small bundles, completely envelopes the inner layer and is distinctly separated from it. The bundles of this layer are of about the same size throughout the strobila, and hence in the posterior segments (fig. 20) are nearly or quite as large as the inner bundles. The origin of the outer layer is similar to that of *H. carioca.* There are no diagonal fibers. Dorso-ventral fibers are most prominent and numerous in the posterior portion of the proglottis. Transverse fibers are not present except a few in the posterior region (fig. 18, *tm*), and a few in the anterior region (fig. 15, *tm*), some of which have a special connection with the cirrus pouch.

Excretory System.—The dorsal canals lie some distance directly dorsal to the ventral canals (figs. 15, 18, 20). The former measure 15 μ to 20 μ in diameter in the anterior segments, and 9 μ to 15 μ in the posterior segments; the ventral canals in the most anterior segments have a diameter the same as that of the dorsal canals, while posteriorly they measure from 20 μ to 35 μ. A transverse canal connects the ventral canals in the posterior part of each segment. There is a basket-like plexus of small canals (figs. 15, 19, *xpl*) in connection with each ventral canal in the posterior half of the proglottis.

In the scolex the canals of both sides turn inward and approach each other as they pass forward. The dorsal canal (fig. 11, *dc*) soon turns outward again and describes a loop around the posterior surface of the sucker, returning back toward the ventral surface close behind the cerebral commissure. From the region of the dorsal vessel where it passes behind the commissure two small canals (figs. 11, 17, *er*), one dorsal and one ventral, extend forward to enter the rostellum near its base, each joining in the anterior portion of the latter a corresponding canal from the dorsal vessel of the other side. There are accordingly two closed loops of the excretory system extending forward into the rostellum, as in *Hymenolepis carioca* and *H. diminuta,* but quite different from them in that they form connectives right to left, instead of dorsal to ventral.

The dorsal canal continues toward the ventral surface, passes around the posterior face of the ventral sucker, and after completing the circuit curves outward and forward to pass anteriad between the dorsal and ventral sucker (fig. 17, *dc*). The ventral canal (fig. 11, *vc*) forms first a loop behind the dorsal sucker, posterior to and smaller than the loop of the dorsal vessel, then, returning toward the ventral surface, forms a second loop behind the ventral sucker also smaller than and posterior to the corresponding loop of the dorsal vessel. The returning limb of the dorsal loop of the ventral vessel crosses the outgoing loop on its anterior side. It is connected with the latter near the region of crossing by two or three small vessels, and continues ventrad as the outgoing limb of the ventral loop. The recurrent limb of the ventral loop turns outward like the corresponding limb of the dorsal vessel, passes behind the latter, and extends between the suckers toward the lateral surface of the scolex, finally turning anteriad to run forward in the same frontal plane as the dorsal vessel, between it and the surface of the head (figs. 11, 16, 17, *vc*). During this portion of the course of the two canals they are connected by numerous smaller vessels which pass at intervals from the dorsal canal forward and outward to the ventral vessel. The dorsal canal of each side finally unites with the ventral canal to form a loop right and left of the rostellum. The loops lie in nearly the same transverse plane. In two specimens examined the dorsal limb of the right-hand loop came from the ventral vessel, of the left-hand loop from the dorsal vessel (fig. 16, broken lines).

Reproductive Organs.—The three testes (figs. 15, 19, 20, *t*) are located posteriorly and toward the dorsal surface in the median field, ordinarily two to the left and one to the right of the median line. They are at their maximum size in segments 160 to 170, where they measure 90 μ to 115 μ through their largest diameter. The vasa efferentia are wide, short tubes uniting to form the vas deferens (fig. 15) which extends forward near the median line. Before entering the cirrus pouch it passes beyond the base of the latter and then folds back to form a small loop in which are commonly found one or two vesicular enlargements (fig. 15, *vs*), representative of the prominent seminal vesicle of *Hymenolepis carioca* or *diminuta.*

The cirrus pouch is a large, elongated, cylindrical structure attaining a maximum size of about 300 μ in length by 60 μ in diameter. It extends from the median line near the anterior end of the proglottis, passing with the vagina above the excretory canals and lateral nerve, backward and outward to the genital pore. A very thin layer of longitudinal muscle fibers forms its outer boundary. In mature segments the vas deferens is expanded within the cirrus pouch to a large seminal vesicle (fig. 15, *vs'*) which almost completely fills its posterior portion. The vas deferens continues distally from the seminal vesicle as a tube 15 μ to 20 μ in diameter, upon the outer surface of which is a layer of small nuclei. After a short distance it bends back toward the base of the pouch, gradually becoming smaller, and, reduced finally to a diameter of 3 μ to 4 μ, opens into the proximal end of the cirrus. The cirrus (fig. 15, *ci*) is a long, powerful organ, slightly coiled, equal to or greater than the cirrus pouch in length, and measures 15 μ to 20 μ in diameter. It possesses a thick wall, smooth outwardly but lined inside with stout bristles, best developed toward its outer end, where they are 6 μ to 10 μ in length. The arrangement of the organs within the cirrus pouch is similar to that of *Drepanidotaenia lanceolata* (Wolffhügel 00a). Most of the fibers of the transverse muscle system in this region extend between the left side of the proglottis and the base of the cirrus pouch (fig. 15, *br*). The remaining few (*tm*) continue across to the other side of the segment. Within the pouch is found a further system of fibers (fig. 15, *cr*) extending between the proximal end of the cirrus and the base of the pouch. Some of them are apparently continuations of the other fibers (*br*) just mentioned. These two aggregations of fibers seem to serve the functions of retractors of the cirrus pouch and cirrus, respectively.

The genital cloaca is from 30 μ to 50 μ deep. Into it open the cirrus and the vagina, the former posterior and dorsal to the latter. Although the opening of the vagina (fig. 19, *vg*) into the cloaca is very narrow, the lumen of its distal portion is wide and capacious, a condition which becomes more pronounced as the segments grow older, and the vagina begins to function as a sperm receptacle. It is covered by a prominent layer of nuclei. The widening of the vagina is accompanied by the appearance of ridges or rugae of the cuticula, the largest of which project 4 μ to 5 μ into the cavity. They are very thin and close together, and run around the vagina in a circular direction, so that in a longitudinal section they appear as a thick coat of cilia. It is likely that in many cases in which cilia have been described lining the cuticula-covered inner surface of the vagina, it is a question, not of cilia, but of projections similar to these ridges. At the base of the cirrus pouch the vagina, becoming narrowed to a diameter of 10 μ to 15 μ, turns backward beneath the former, and passes posteriad to a point beneath the yolk gland (fig. 15, *yg*).

This organ is a compact, ovoid body with a maximum size of 90 μ, lying towards the dorsal surface, beneath the points of union of the vasa efferentia of the testes.

The shell gland (fig. 15, *sg*) is about 50 μ in diameter, and lies immediately beneath the yolk gland.

The ovary (fig. 20, *ov*) is a simple sac-like structure, slightly elongated transversely, with a depression behind giving it a somewhat lenticular shape. From segment 158 to 168 the ovary increases in size very rapidly. In the former it has a transverse diameter of but 60 μ, in the latter it has attained a width of 210 μ, a thickness of 100 μ, and a length of 135 μ. It lies in the ventral half of the proglottis, entirely anterior to the posterior limits of the yolk and shell glands. The maximum size of the ovarian ovum is 12 μ.

The uterus develops in front of the yolk and shell glands, immediately dorsal to the ovary. In segment 160 it is represented by a little lenticular mass of cells 50 μ in diameter, lying ventral to the base of the cirrus pouch, and connected with the shell gland by an almost straight cord of cells 60 μ in length. In the segments immediately following, the anterior mass of cells has begun to arrange itself into a layer enclosing a central cavity; the uterine duct from the shell gland has grown longer, and become bent back and forth. The uterus continues to increase in size, and in segment 168 extends forward to the anterior border of the proglottis, a distance of 125 μ, and measures in the transverse diameter 180 μ. The second following segment (170) has a well-defined layer of cells upon the outer surface of the uterus, and this layer (fig. 19) becomes progressively thicker and more prominent toward the posterior end of the strobila. As the eggs pass out of the ovary it shrinks rapidly, and in segment 174, where all the eggs have entered the uterus, has entirely disappeared. The uterus expands forwards and outwards toward the surface, and more slowly backwards, as a simple sac without infoldings, differing thus from *Hymenolepis carioca* and *H. diminuta*.

In the last dozen segments of the worm, partial ruptures occur in the continuity of the strobila (fig. 19), caused perhaps by the sudden contraction of the segments when the worm was killed. In these segments the anterior end of the uterus is more or less exposed. Whether such action takes place by natural muscular contractions is uncertain, but there is certainly a tendency in this direction. Consequent upon the separation of a ripe segment from the strobila, however brought about, a large area of the surface of the uterus is laid bare, and in this area a thin membrane is all that separates the embryos from the outer world, facts which may play a part in their dispersal.

With regard to the systematic position of *T. megalops,* while it differs considerably in a number of points from the type of *Hymenolepis,* it is scarcely possible at the present time to define its affinities more accurately than to give it, for the sake of its three testes and unilateral genital pores, the place of an aberrant species in the above genus.

ON THE GENUS HYMENOLEPIS

The genus *Hymenolepis* in its present status is composed of a considerable number of species all characterized by the possession of three testes and unilateral genital pores. Cohn (99, 99a, 99b, 00a) divides the genus thus characterized into two subgenera upon the basis of the number of hooks. Upon *a priori* grounds alone such a division seems exceedingly artificial, and indeed Wolffhügel (00, 00a) has demonstrated by two or three cases that it is false and misleading by reason of the non-correspondence of the superficial characters taken by Cohn to more important internal relations. There is still further evidence in this regard.

H. carioca is clearly so similar to *H. diminuta* as to belong in the same genus. Since the rostellum is unarmed it would also, following Cohn's classification, fall in the same subgenus *Hymenolepis* s. str. Specimens in my possession of *Hymenolepis* sp.? from one of the gulls, *Larus Franklinii* (?) possess a freely extensible rostellum armed with 10 hooks of the form typical of the now disused genus *Dicranotaenia* Raill. Upon the basis of Cohn's classification we should refer it at once to the subgenus *Drepanidotaenia.* The form possesses three testes and in the details of cirrus pouch, the two seminal vesicles, seminal receptacle, ovary, yolk gland, and anlage of uterus shows striking similarities to *H. carioca.* There are the same number of inner muscle bundles and a definite system of diagonal muscles as in the latter. These two forms are very closely allied, and are much more similar to one another than to *H. diminuta.* The structural resemblance is certainly too great to allow of their separation into two different subgenera, if one of the subgenera is also to contain *H. diminuta.* To arrange them according to Cohn's system it would be necessary either to neglect their internal anatomy or to suppose that *H. carioca* in young stages possesses 8–10 hooks which are afterwards lost. That the latter circumstance occurs, however, seems improbable, otherwise we should not expect to find a specimen, as already noted, retaining hooks on the suckers, and at the same time with no trace of armature upon the rostellum. The foregoing facts, I believe, furnish a very good demonstration of the untenability of Cohn's division of the genus. A division may be necessary, but it must be made upon a different basis than that attempted by Cohn. Apart from this question it is not even certain that he has wisely modified the definition of the genus in restricting the number of testes to three. In Blanchard's description the number of testes is given as very few, most often three, which allows a desirable degree of latitude to this character.

The form described by Jacobi (98) as *Taenia inflata* Rud. possesses but two testes, and hooks which, while of the same form, are only a third as large as those of the type specimens examined by Krabbe. A tape-worm which Cohn (98a) considers the true *T. inflata* Rud., agreeing in all respects with Krabbe's description, possesses three testes, and he is accordingly of the opinion that Jacobi has described another species. The latter is possibly to be identified with *Taenia spiculigera* Giebel 1866. A similar form with two testes, from *Fulica americana,* has hooks 37 μ in length, somewhat larger than those of Jacobi's specimens, in this respect agreeing with *T. spiculigera* more closely than the latter. The suckers of my specimens are armed. In anatomical details this form agrees with Jacobi's description. It has, however, a seminal vesicle outside the cirrus pouch, besides the one within described by Jacobi. Except for the lack of agreement in the number of testes, *Taenia spiculigera* (?) is very like *H. carioca* and but for this difference would undoubtedly fall in the same genus. That this difference is not so important as may seem is shown by the fact that the number of testes in segments of *H. diminuta,* normally three, sometimes varies in either direction to two or four, as Grassi (88) has shown. I am able to confirm Grassi's observations, in part, as I have sections of *H. diminuta* showing four testes in some segments. It is therefore questionable whether such a difference is sufficient to separate generically two forms otherwise similar, whose lack of agreement in this regard may be explained as the result of a slight variation, which, although occurring but occasionally in one, has become permanent and normal in the other. According to this view *Taenia spiculigera* (?) should be brought under *Hymenolepis*.

BIBLIOGRAPHY

Braun, M.

94–00. Vermes. Bronn's Klassen und Ordnungen des Thierreichs. Bd. IV, Abt. 1 b. Cestodes.

Cohn, L.

98a. Untersuchungen über das centrale Nervensystem der Cestoden. Zool. Jahrb., Anat., XII., pp. 89–160, pls. VI–IX, 9 text figs.

99. Zur Systematik der Vogeltaenien. Cent. f. Bakt. u. Parasitenk., Bd. XXV, No. 12, pp. 415–22.

99a Zur Systematik der Vogeltaenien, II. Cent. f. Bakt. u. Parasitenk., Bd. XXVI, pp. 222–27.

99b. Zur Systematik der Vogeltaenien, III. Zool. Anz., Bd. XXII, pp. 405–8.

00. Zur Systematik der Vogeltaenien, IV. Cent. f. Bakt. u. Parasitenk., Bd. XXVII, pp. 325–28.

Creplin, Fr.

25. Observationes de Entozois. P. I. Gryphisw. 86 pp., 1 pl. (Brief synopsis in Braun 94–00.)

29. Novae observationes de entozois. Berolini. 134 pp., 2 pl. (Brief synopsis in Braun 94–00.)

Diesing, C. M.

50. Systema Helminthum. I. Vindobonae. 680 pp.

64. Revision der Cephalocotyleen. Abth. Cyclocotyleen. Sitzbr. k. Akad. Wien, XLIX, I Abth., pp. 357–430.

Dujardin, F.

45. Histoire naturelle des Helminthes, ou vers intestinaux. Paris. 654 pp., pls. I–XII.

FUHRMANN, O.

95. Beitrag zur Kenntnis der Vogeltaenien. Revue Suisse de Zool., T. III. pp. 433–58, pl. XIV.

GIEBEL, C.

66. Die im zoologischen Museum der Universität Halle aufgestellten Eingeweidewürmer nebst Beobachtungen über dieselben. Zeitschr. f. d. ges. Naturwiss., Bd. XXVIII, Thl. II, pp. 253–73.

GRASSI, B.

88. *Taenia flavopunctata* Weinl., *Taenia leptocephala* Crepl., *Taenia diminuta* Rud. Atti R. Accad. d. sc. Torino, Vol. XXIII, pp. 492–501, 1 pl.

JACOBI, A.

98. Über den Bau der *Taenia inflata* Rud. Zool. Jahrb., Syst., Bd. XII, pp. 95–104, 1 pl.

LÜHE, M.

94. Zur Morphologie des Taenien-scolex. Inaug. Diss. Königsberg i. Pr. 133 pgs., 12 figs.

96. Zur Kenntnis der Musculature des Taenien-körpers. Zool. Anz., Bd. XIX, pp. 260–64, 4 figs.

MAGALHAES, P. S. DE.

98. Notes d'helminthologie brésilienne 8. Deux nouveaux Ténias de la Poule domestique. Arch. de Parasit. I, pp. 442–49, 6 figs.

MINGAZZINI, P.

99. Osservazioni generali sul modo di adesione dei Cestodi alla parete intestinale. Atti. Accad. Lincei (5), Vol. 81, pp. 597–603, 6 figs. Also Arch. Ital. Biol., XXXII, pp. 340–50. Abstract Zool. Jahresbericht.

STILES, CH. WARDELL.

96. Report upon the Present Knowledge of the Tapeworms of Poultry. Bull. No. 12, Bur. An. Ind., U. S. Dept. Agric., Washington, D. C., pp. 1–79, pls. I–XXI.

TOWER, W. L.

00. The Nervous System in the Cestode *Moniezia expansa*. Zool. Jahrb., Anat., Bd. XIII, pp. 359–84, pls. 21–26.

WOLFFHÜGEL, K.

00. Beitrag zur Kenntnis der Vogelhelminthen. Inaug. Diss. Univ. Basel. pp. 204, pls. I–VII.

00a. *Drepanidotaenia lanceolata* (Bloch). Cent. f. Bakt. u. Parasitenk., Bd. XXVIII, pp. 49–56, 6 figs.

ZSCHOKKE, F.

88. Recherches sur la structure anatomique et histologique des Cestodes. Mem. de l' Institut national. Genevois. T. XVII. pp. 396, pls. I–IX.

EXPLANATION OF PLATES

Figures outlined with camera except as stated otherwise.

ABBREVIATIONS

adc Dorsal anterior nerve commissure.
ag Anterior ganglion of lateral nerve.
an Anterior nerve from cerebral ganglion.
avc Ventral anterior nerve commissure.
br Retractor of cirrus pouch.
ci Cirrus.
cg Cerebral ganglion.
cv Transverse cerebral commissure.
cp Cirrus pouch.
cr Retractor of cirrus.
dc Dorsal excretory canal.
dd Dorsal halves of dorso-ventral commissure.
dm Diagonal muscles.
er Excretory loops of rostellum.
fga Anlage of female glands.
gc Genital cloaca.
im Inner longitudinal muscles.
ln Main lateral nerve.
mg Middle ganglion of lateral nerve.
mp Muscle bands.
my Myoblasts.
na Accessory lateral nerve. In fig. 16, point of union with cerebral complex.
mn Median nerve. In fig. 16, point of union with cerebral complex.
nr Rostellar nerve ring.
om Outer longitudinal muscles.
ov Ovary.
pc Prostate(?) cells of vas deferens.
pdc Dorsal posterior nerve commissure.
pg Posterior ganglion of lateral nerve
pr Protractors of cirrus pouch.
pvc Ventral posterior nerve commissure.
rc Subcuticular cells of rostellum.
rm Muscle layer of rostellum.
rn Nerve to rostellum.
ros Rostellum.
rp Cavity of rostellum.
rvn Apical branch from main lateral nerve to rostellar ring.
sg Shell gland.
sm Limiting membrane of cirrus pouch.
sr Seminal receptacle.
t Testis.
tm Transverse muscles.
ut Uterus.
vv Ventral halves of dorso-ventral commissure.
vc Ventral excretory canal.
vd Vas deferens.
ve Vas efferens.
vg Vagina.
vgs Vaginal sphincter.
vs Seminal vesicle. In fig. 4, vesicle of cirrus pouch.
vs' Seminal vesicle of cirrus pouch.
xpl Plexus of excretory vessels.
x Dorsal posterior inner nerve commissure.
yg Yolk glands.

Plate XXIII

Hymenolepis carioca

Fig. 1. Ventral view of segments. Toto preparation. ×245.
Fig. 2. Dorsal view of very young segments. ×245.
Fig. 3. Hooks from suckers. Free-hand drawing. ×2600.
Fig. 4. Cirrus pouch and seminal receptacle. Transverse section. ×1100.
Fig. 5. Hook from onchosphere. Free-hand drawing. ×2000.
Fig. 6. Onchosphere with membranes. From specimen in formalin. ×535
Fig. 7. Transverse section through anterior region of proglottis. ×600.

Plate XXIV

H. carioca

Fig. 8. Scolex. Toto preparation. ×185.
Fig. 9. Ventral view of posterior end of strobila. Toto preparation. ×50.
Fig. 10. Frontal section of scolex. ×180.

H. megalops

Fig. 11. Excretory system in scolex. View from anterior. Reconstructions from transverse sections through scolex behind the rostellum. ×55.
Fig. 12. Frontal section of scolex. ×55.
Fig. 13. Young embryo. ×600.
Fig. 14. Six-hooked embryo. ×600.

Plate XXV

H. megalops

Fig. 15. Dorsal view of mature segment (No. 172). Reconstruction from sections. ×135.

Fig. 16. Transverse section through the anterior region of scolex. The broken lines are anterior to the plane of section. ×45.

Fig. 17. Transverse section of scolex at level of cerebral commissure. ×45.

Fig. 18. Transverse section through the posterior region of one of the first 35 segments. ×120.

Fig. 19. Frontal section through a mature segment (No. 180). ×120.

Fig. 20. Transverse section through the anterior region of a mature segment (No. 168). ×120.